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# Variations of the Viscosity of Thickened Liquids Used to Treat Pediatric Dysphagia

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## Abstract

Speech-language pathologists (SLPs) working with infants who are diagnosed with dysphagia use a variety of commercial thickeners and food products to thicken liquids with varied recipes reported. The treatment of Dysphagia is hindered by the use of various recipes used for thickening liquids in swallowing and feeding therapy. At present, there is limited standardized methodology for determining the viscosity of liquid levels and dietary modifications. It was reported that SLPs in different facilities across the nation use a variety of thickening agents and recipes as therapeutic measures for patients diagnosed with dysphagia. Limited research has been completed in related to children and infants with dysphagia. Two commonly reported food products used for infants and children were infant rice and oatmeal cereals. Thik & Clear currently has no age restriction for consumption. Viscosity was tested to determine the thickness, measured in Centipoise (cP), of each thickening agent mixed with infant formula. The values were then compared to the national dysphagia diet liquid (NDDL) levels to determine which thickening agent resulted in the desired viscosities. The thickeners were mixed with common infant formulas and soy formulas to determine if the type of formula impacted the viscosity. Lastly, the viscosity of Varibar barium, a common liquid utilized during instrumental evaluation, was measured to compare the viscosity of the evaluation liquid to the recommended liquid in order to determine if the assumed thickness of the prescribed thickened liquids was actually being met. Overall, Thik & Clear was the most consistent thickener tested and the only thickening agent that consistently measured within the nectar range suggested by NDDL and Varibar Nectar barium. Food thickening agents, infant rice and oatmeal cereals, resulted in significantly lower viscosities when compared to NDDL and Varibar Nectar barium. Separation of the thickening agent from the formula was evident. Liquids thickened with infant oatmeal cereal have slightly more consistent viscosities within each sample compared to infant rice cereal.

**Keywords: Dysphagia; Varibar barium; Viscosity; Commercial thickeners**

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## Introduction

It has been reported that SLPs across the nation use a variety of thickening agents and recipes as therapeutic measures for infants and children diagnosed with dysphagia (need citation). Dysphagia is defined as difficulty with swallowing and includes a range of swallowing disorders [1,2]. A range of specialists, such as SLPs, occupational therapists (OTs), dieticians, registered nurses (RNs), and pediatricians work with this patient population [3]. Research states that 25% to 45% of the infant and pediatric population has feeding and swallowing difficulties. This number increases up to 80% for those who are classified as developmentally delayed [4,5]. Observed feeding difficulties with infants have increased with the rise in survival rates of preterm infants [4,6]. Infants with dysphagia have an increased risk for dehydration, malnutrition, failure to thrive, and respiratory complications such as pneumonia [3,6-8].

Methods for dysphagia management in infants include adjustment of infant feeding position, lingual motor exercises, pacing of feeding rhythm, and oral motor stimulation [7]. Other infant dysphagia management techniques manipulate the flow of the liquid by adjusting the nipple size, temperature, and the viscosity of the liquid [7,9]. The therapeutic strategy of thickening liquids is most commonly utilized with infants who exhibit dysphagia and are at risk for aspiration [3,6,7]. Thickening agents have been proven to reduce flow rate of the liquid by increasing viscosity and to improve the coordination of the suck, swallow, breathe pattern providing protection to the airway [3,5,6]. However, adverse health effects of thickening liquids such as dehydration,

Necrotizing enterocolitis (NEC), and pulmonary issues are possible [6]. Researchers are unable to make conclusions about the health consequences of thickened liquids [6]. However, concerns about the standardization and clinical guidelines of thickened liquids for infants are evident considering the limited amount of research.

Common products used to thicken liquids with infants include gum-based thickeners (e.g. Thik & Clear) and infant rice and oatmeal cereals [4,5,7,10,11]. Arsenic has been reported to be present in rice and elevated levels of exposure to arsenic may lead to bladder and lung cancer [10]. Infants and children may be exposed to large amounts of rice, and consequently arsenic, when rice cereal is the food product utilized for thickening. Due to this fact, the AAP group suggests that oatmeal cereal be used rather than rice cereal as a thickening agent [10].

Other disadvantages associated with the use of rice cereal for thickening include excessive weight gain, constipation, and is ineffective at thickening human milk [3,4,6]. The addition of rice cereal to formula provides an extra 15 calories per tablespoon and results in a 25% increase of caloric intake [4]. Human milk contains amylase which breaks down carbohydrates and prevents the rice from acting as a thickening agent [4].

SimplyThick, a gel-based thickener, was a common commercial product used with infants. In 2011, the FDA released a warning for the use of SimplyThick with infants who were born before 37 weeks gestation. SimplyThick may have been causing NEC in premature infants. Consequently, SimplyThick now has an age restriction of one year and older, and the company does not recommend SimplyThick for those under the age of 12 with a history of NEC.

Examinations ranging from bedside swallow studies to formal video-fluoroscopic swallow studies (VFSS) determine the suggested therapy practice and thickness level of liquids [7,9]. Liquid barium mixtures are required during a VFSS to observe the swallowing process in the patients and determine where difficulties occur. Research has found that nearly 50% of patients who were able to safely swallow Varibar thin barium could not swallow a water and barium mixture without aspirating even though the viscosities of the pure barium and the barium mixture were the same [8]. This illustrates the discrepancies between prescribed liquids and barium used during testing. It is reported that the viscosities of assessment and prescription are unlikely to match using current methods [3,7-9].

Stuart and Motz [9] investigated the baseline viscosities for commercial barium products and infant formula thickened with various products. They measured small samples, 0.5 ml, that does not best represent the volume typically used in treatment with infants with dysphagia. Stuart and Motz [9] found that cereal mixtures had a larger standard deviation compared to commercial thickeners and barium and were between nectar and thin liquid levels according to the NDDL guidelines. Oatmeal cereals were reported to be the most inconsistent [5]. There was a problematic and significant difference between barium mixtures and the formulas prescribed as treatment for infants with dysphagia [5]. These inconsistencies cause transitioning from assessment to treatment difficult.

Standardization among the viscosities of thickened liquids, preparation, and recipes is needed. Directions for thickening liquids are often vague and difficult to follow, and a large percentage of caregivers are not properly trained in the preparation procedures [1]. Professionals that work with thickened liquids, including SLPs and registered dieticians, lack a consistent use of the descriptive labels applied to various consistencies of thickened beverages [1]. In an effort to establish standards of practice, the national dysphagia diet level (NDDL) instituted specific terminology and viscosity ranges (Table 1). However, such objective measurement, mainly implemented through viscometers, is impractical for most clinical settings [1]. Therefore, the line spread test is an attempt to provide a standardization tool that is practical within the clinical setting. Line spread testing was determined to be consistent enough to be used as a screening tool for viscosities of thickened liquids and be utilized as a staff training tool to demonstrate the difference between nectar and honey thick liquids [1].

**Table 1:** National Dysphagia Diet Levels.

| | |
|---|---|
| Thin | 1-50 centiPoise (cP) |
| Nectar-like | 51-350 cP |
| Honey-like | 351-1,750 cP |
| Spoon-thick | > 1,750 cP |

## Methods

Two Brookfield DV2T Viscometers and one Brookfield DV3T Viscometer were used to collect the viscosity levels. Sixteen ounces of bottled water was regulated to room temperature, approximately 25°C in a Brookfield TC-550 heat bath. The formulas selected for this study were Gerber Goodstart for Supplementing, Enfamil Infant, Similac Advance, Gerber Goodstart Soy, Enfamil Soy, Similac Soy, Pregestimil, Nutramingen, Similac Alimentum, and Gerber Gentle.

The standardized process for preparing each formula consisted of adding the formula to the water according to the packaged instructions and was shaken for approximately 20 s. For commercial thickening products, Thik & Clear was tested. For food thickening agents, infant rice cereal or infant oatmeal cereal was added to the formula according to the recipe being tested. The recipes utilized were 15 cc or 20 cc of food product per 2 oz of liquid, depending on targeted viscosity. For rice cereal, 15 cc was measured for nectar thick viscosity and 20 cc was measured for honey thick viscosity. When Varibar barium was included in the mixture, the recipe was 1 oz of Varibar barium, 1 oz of formula, and 15 cc or 20 cc of infant rice cereal, depending on the targeted viscosity.

Each mixture was shaken for approximately 20 s. The thickened liquid was poured into a beaker and tested using a Brookfield DV2T Viscometer. All thickened liquids were tested using multipoint averaging of 2 min and 15 s intervals for 23 min. The data was recorded on a spreadsheet and displayed in graphs. The viscosity of Varibar barium was tested using a small sample adapter and Enhanced UL Adapter on the Brookfield DV3T Viscometer. Samples of thin, half nectar, thin nectar, and nectar were used to determine the viscosity of Varibar barium.

## Results and Discussion

The results are depicted in Figures 1-6. The final outcomes have been summarized in Table 2. During the 23 min of testing, the infant rice cereal appeared to form a distinct separation from the formula at five minutes. The infant oatmeal cereal also separated; however, three distinct sections were noted. The cause of separation within the thickened liquids may be related to the chemical structure of the rice cereal and oatmeal being unable to bind to the liquid. The separation may be the cause of the significant difference between initial viscosities and final viscosities of formulas mixed with infant

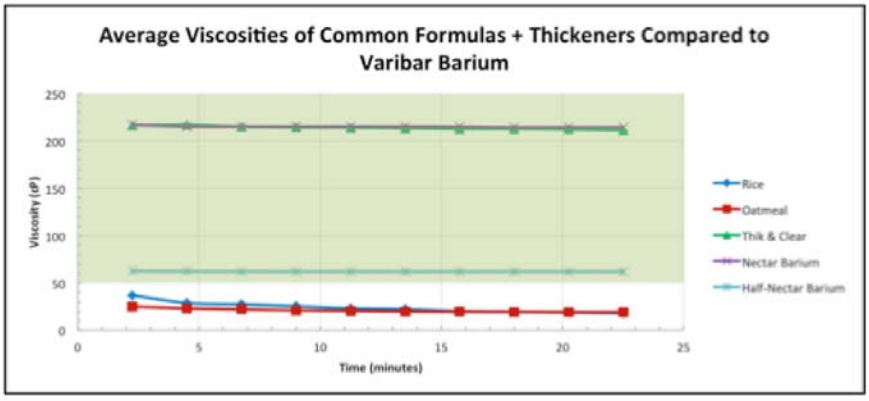


**Figure 1:** The average viscosities of three infant formulas (Gerber Goodstart for Supplementing, Similac Advanced, and Enfamil Infant) mixed with rice cereal, oatmeal cereal, or Thik & Clear were compared to Varibar barium viscosity levels. The NDDL nectar thick range is represented by the green shaded area. Thik & Clear fell within NDDL nectar range. The average of the common formulas with rice cereal and with oatmeal cereal fell below NDDL nectar range and Varibar barium viscosity levels.

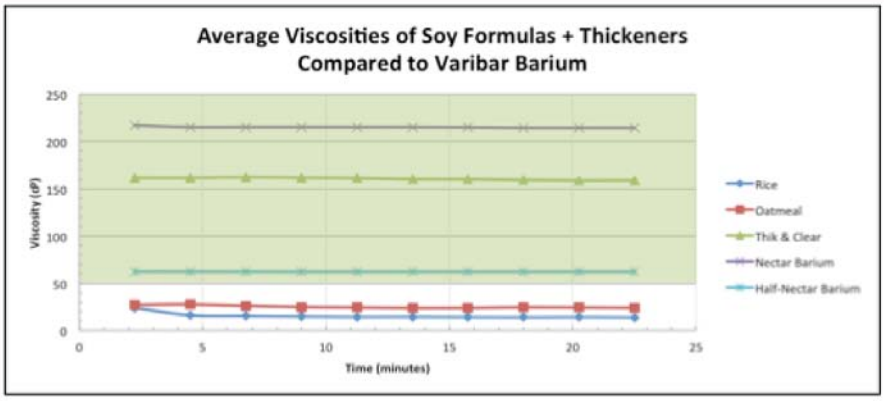


**Figure 2:** The average viscosities of three infant formulas (Gerber Goodstart Soy, Similac Soy, and Enfamil Soy) mixed with rice cereal, oatmeal cereal, or Thik & Clear were compared to Varibar barium viscosity levels. The NDDL nectar thick range is represented by the green shaded area. Thik & Clear fell within NDDL nectar range and between Nectar and Half-Nectar Varibar barium. The average of the soy formulas with rice cereal and with oatmeal cereal fell below NDDL nectar range and Varibar barium viscosity levels.

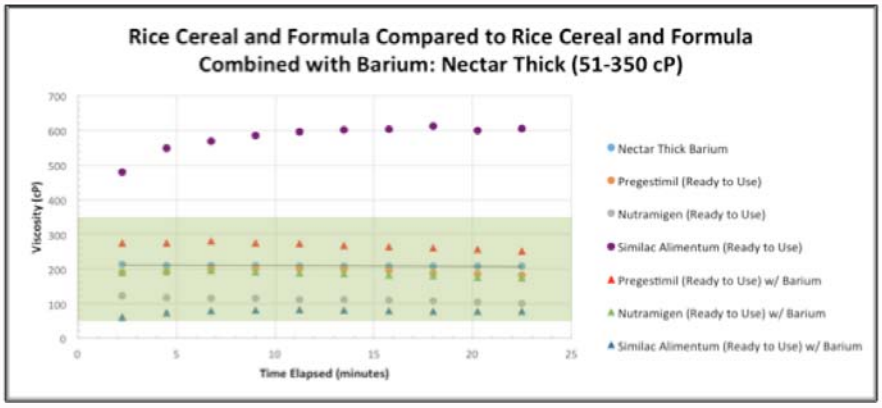


**Figure 3:** The viscosities of ready to use formulas mixed with rice cereal were compared to ready to use formulas mixed with rice cereal and barium. The trials were also compared to the Varibar nectar thick barium viscosity level. The NDDL nectar thick range is represented by the green shaded area. The majority of the trials fell within the designated range.

rice and oatmeal cereal.

A limitation of the study was access to a large volume of Varibar barium. Therefore, a small sample adapter and Enhanced UL Adapter were used to test the viscosity of Varibar barium. The thin nectar barium was made from 30 ml of thin Varibar barium and 30 ml of Nectar Varibar barium. Another 30 ml of Nectar Varibar barium was added to the thin nectar to make half nectar.

Liquid viscosities varied when Varibar thin barium was mixed with formula and rice cereal. Varibar thin barium with infant rice cereal and ready to use formulas reached the targeted nectar range

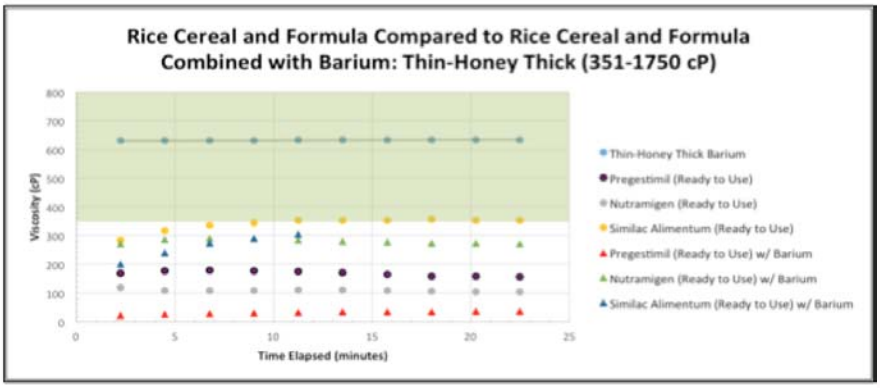


**Figure 4:** The viscosities of ready to use formulas mixed with rice cereal were compared to ready to use formulas mixed with rice cereal and barium. The trials were also compared to the Varibar thin-honey barium viscosity level. The NDDL honey thick range is represented by the green shaded area. The majority of the trials fell below NDDL honey range and the Varibar barium viscosity level.

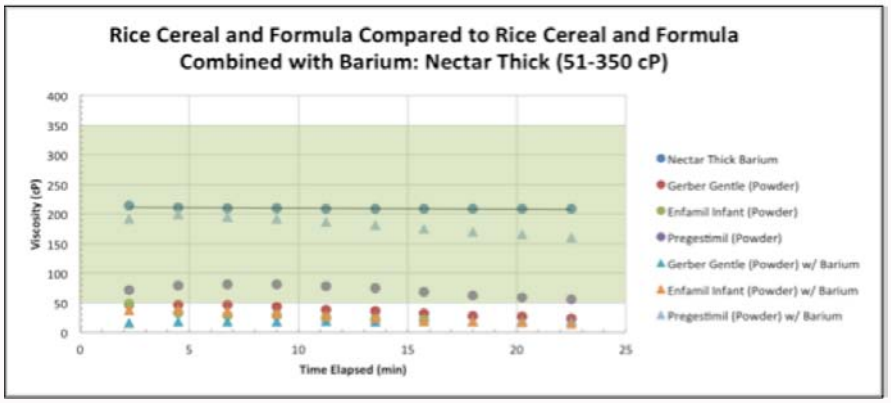


**Figure 5:** The viscosities of powder formulas mixed with rice cereal were compared to powder formulas mixed with rice cereal and barium. The trials were also compared to the Varibar nectar thick barium viscosity level. The NDDL nectar thick range is represented by the green shaded area. Gerber Gentle, Enfamil infant, Enfamil infant with barium and Pregestimil with barium all fell below the designated viscosity range. Gerber Gentle with barium and Pregestimil fell within the designated viscosity range.

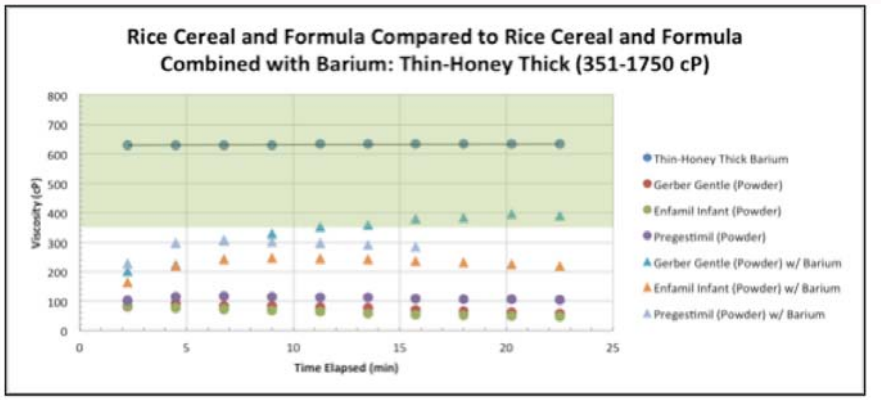


**Figure 6:** The viscosities of powder formulas mixed with rice cereal were compared to powder formulas mixed with rice cereal and barium. The trials were also compared to the Varibar thin-honey barium viscosity level. The NDDL honey thick range is represented by the green shaded area. The majority of the trials fell below NDDL honey range and the Varibar barium viscosity level.

viscosity. Mixtures with Varibar barium, infant rice cereal, and powdered formula tested below targeted viscosity ranges. Mixtures with formula and infant rice cereal without Varibar barium also tested at a lower viscosity outside of the targeted range.

Thik & Clear provided a consistent level of viscosity. However, at the conclusion of testing, dime and quarter sized masses of gel and formula were noted in the bottom of the beaker. This indicated the thickener and formula powder did not completely disperse within the liquid. The cause of the "clumps" may have been a result of the formula making and thickening processes. The Thik & Clear label specifies mixing directions for a 4-oz single serving or for multiple servings. Sixteen ounces of fluid was needed for the viscometers

**Table 2:** Viscosities of Commonly Used Formulas (cP).

| Time (minutes) | Nectar Barium | Rice | | | Oatmeal | | | Thik & Clear | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Enfamil | Gerber | Similac | Enfamil | Gerber | Similac | Enfamil | Gerber | Similac |
| 2.25 | 216.9 | 29.71 | 34.7 | 47.18 | 21.17 | 25.8 | 28.85 | 204.8 | 176.2 | 268.8 |
| 4.5 | 215.3 | 23.66 | 23.86 | 39.6 | 20.26 | 22 | 27.79 | 204.8 | 174.2 | 272 |
| 6.75 | 215.3 | 21.98 | 24.43 | 36.29 | 18.96 | 21 | 26.74 | 202.4 | 172.2 | 271.2 |
| 9 | 215.3 | 21.46 | 20.45 | 34.75 | 18.77 | 19.6 | 25.78 | 202.4 | 170.2 | 270.4 |
| 11.25 | 215.3 | 20.59 | 17.38 | 31.97 | 18.91 | 18 | 25.06 | 201.6 | 169.6 | 271.2 |
| 13.5 | 215.3 | 19.15 | 17.95 | 29.86 | 19.06 | 16.4 | 24.91 | 200 | 169 | 271.2 |
| 15.75 | 215 | 18.38 | 16.85 | 26.06 | 19.2 | 15.2 | 25.06 | 198.4 | 168.6 | 271.2 |
| 18 | 214.4 | 17.81 | 16.27 | 25.39 | 19.58 | 13.8 | 25.3 | 197.6 | 168.6 | 272 |
| 20.25 | 214.4 | 17.14 | 16.22 | 23.47 | 19.25 | 13.6 | 25.3 | 196.8 | 167 | 272.8 |
| 22.5 | 214.4 | 16.56 | 15.7 | 22.13 | 19.06 | 13 | 25.44 | 196 | 166.2 | 272 |
| Average | 215.16 | 20.64 | 20.38 | 31.67 | 19.42 | 17.84 | 26.02 | 200.48 | 170.18 | 271.28 |
| Standard Deviation (STD) | 0.74 | 3.72 | 5.63 | 7.53 | 0.71 | 4.01 | 1.27 | 3.04 | 2.98 | 1.04 |
| (STD/Average)*100 | 0.34 | 18.02 | 27.62 | 23.78 | 3.66 | 22.48 | 4.88 | 1.52 | 1.75 | 0.38 |
| Corr Coefs between formula and Nectar Barium | | 0.95 | 0.91 | 0.91 | 0.65 | 0.9 | 0.75 | 0.82 | 0.86 | -0.91 |
| **Time (minutes)** | **Nectar Barium** | **Enfamil Soy** | **Gerber Soy** | **Similac Soy** | **Enfamil Soy** | **Gerber Soy** | **Similac Soy** | **Enfamil Soy** | **Gerber Soy** | **Similac Soy** |
| 2.25 | 216.9 | 33.55 | 21.46 | 17.42 | 28.7 | 29.23 | 24.53 | 103.2 | 221.6 | 161.4 |
| 4.5 | 215.3 | 20.88 | 14.3 | 13.49 | 28.42 | 30.48 | 24.72 | 103.8 | 221.6 | 160.4 |
| 6.75 | 215.3 | 19.82 | 13.82 | 12.24 | 26.78 | 28.66 | 23.76 | 105 | 222.4 | 160.2 |
| 9 | 215.3 | 16.66 | 14.11 | 13.39 | 25.58 | 27.02 | 22.51 | 105.2 | 221.6 | 159.4 |
| 11.25 | 215.3 | 14.88 | 14.35 | 13.78 | 25.25 | 26.5 | 21.8 | 105 | 220.8 | 159 |
| 13.5 | 215.3 | 14.88 | 14.11 | 14.21 | 25.01 | 25.73 | 21.41 | 105 | 218.4 | 157.8 |
| 15.75 | 215 | 14.88 | 13.87 | 13.8 | 25.63 | 24.91 | 21.74 | 105 | 218.4 | 157.4 |
| 18 | 214.4 | 15.12 | 14.11 | 12.62 | 27.65 | 24.58 | 21.84 | 105.2 | 217.6 | 155.8 |
| 20.25 | 214.4 | 15.31 | 14.11 | 13.15 | 27.65 | 23.86 | 21.98 | 105.2 | 217.6 | 154.6 |
| 22.5 | 214.4 | 15.31 | 13.58 | 12.77 | 27.07 | 23.52 | 22.03 | 105.2 | 217.6 | 154.6 |
| Average | 215.16 | 18.13 | 14.78 | 13.69 | 26.77 | 26.45 | 22.63 | 104.78 | 219.76 | 158.06 |
| Standard Deviation (STD) | 0.74 | 5.54 | 2.24 | 1.37 | 1.27 | 2.25 | 1.17 | 0.66 | 1.89 | 2.31 |
| (STD/Average)*100 | 0.34 | 30.56 | 15.15 | 10.01 | 4.74 | 8.51 | 5.17 | 0.63 | 0.86 | 1.46 |
| Corr Coefs between formula and Nectar Barium | | 0.86 | 0.85 | 0.86 | 0.18 | 0.18 | 0.63 | -0.81 | 0.69 | 0.85 |

utilized in this study. Access to a mixer or blender was not available. Therefore, 4 single servings were made and then combined to test 16 oz of fluid.

## Conclusion

Overall, Thik & Clear was the most consistent thickener tested, with clumps present, and the only thickening agent that consistently measured within the nectar range suggested by NDDL. Food thickening agents, infant rice and oatmeal cereals, resulted in significantly lower viscosities when compared to NDDL. Inconsistent viscosities were noted when testing formulas with rice cereal and then Varibar barium. A discrepancy was noted between Varibar Nectar and Varibar thin honey barium used during instrumental evaluations, as well as nectar and honey thick recipes prescribed for use. However, further testing need to be completed.

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